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Some Examples in Italy

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Publication date
2020

Document Version
Final published version

Published in
Proceedings - Building Simulation Applications, BSA 2019

Citation (APA)
Vodola, V., Nastasi, B., Manfren, M., & Merli, F. (2020). The Acoustic Simulation of Performing Area in the Auditorium: Some Examples in Italy. In G. Pernigotto, F. Patuzzi, A. Prada, V. Corrado, & A. Gasparella (Eds.), *Proceedings - Building Simulation Applications, BSA 2019: 4th IBPSA-Italy Conference* (pp. 245-250). (Building Simulation Applications; Vol. 2020-June). Free University of Bozen Bolzano.

Konferenzbeiträge / Atti / Proceedings

Building Simulation Applications BSA 2019

4th IBPSA-Italy Conference
Bozen-Bolzano, 19th–21st June 2019

Edited by
Giovanni Pernigotto, Francesco Patuzzi,
Alessandro Prada, Vincenzo Corrado, Andrea Gasparella

bu,press
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Cover design: DOC.bz

1st edition
www.unibz.it/universitypress

ISSN 2531-6702
ISBN 978-88-6046-176-6

The Acoustic Simulation of Performing Area in the Auditorium: Some Examples in Italy

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Abstract

The design of auditoria and opera houses requires particular care for the stage area, where several different requirements should be achieved for the performers. Among these, the acoustic quality represents a fundamental aspect, and it differs from the listeners' perspective. Moreover, the performing area in concert halls is often an important area for non-acoustic reasons, since lighting, thermal plants, etc. are often placed in this special zone, and should be properly designed in order to guarantee a high level of global comfort. This paper presents some examples of how to design exhibition zones in opera houses and auditoriums that show both acoustic and technical improvements, both in theory and in architecture.

1. Introduction

The performance area is one of the most important aspects of acoustic design in the design of music spaces and in particular of opera houses. In addition, opera houses have two different spaces, the orchestra pit and the stage, and these are quite different in terms of their acoustics. However, even though in most cases both the singers (on stage) and the musicians (in the pit) cannot hear each other very well, the conductor (visible to both singers and musicians) is able to lead the performance because both the fence and the proscenium can receive direct sound and reflection. The design process should therefore consider many different aspects, ranging from acoustical requirements and flexibility.

In this paper, some example of the design of performing zones in opera houses and auditoria are presented, showing both the theoretical and architectural requirements for acoustical and technical enhancements. Specifically, three main aspects of the design process are analysed: the design of the orchestra pit, the design of the diffusion in the stage, and the design of the acoustic chamber.

2. Materials and Methods

2.1 The Design of the Orchestra Pit

An orchestra pit holds all the musicians during the performance of an opera, which is the reason why this small area is very important when musicians and singers perform together. Since the stage and the pit are in different locations in opera halls, musicians have many difficulties during a performance. Moreover, in the event of a lack of balance between stage and orchestra pit, the acoustic quality of the theatre can be reduced. The acoustic design of the pit should aim to improve the balance between musicians and singers in order to solve these problems (Gade, 1989) and to improve the performance of singers moving across the stage during an opera.

The acoustic design should offer a very flexible variety of acoustics in the orchestra pit, while the fence must provide a satisfactory early reflection from the pit to the point and vice versa, in order to properly link the specific sound characteristics of each musical instrument (Farina et al., 1998; Farina and Tronchin, 2000; Tronchin 2012; Tronchin and Coli, 2015; Tronchin et al., 2020).

Final acoustic design was obtained for the Teatro Comunale in Treviso, simulating different pit configurations that could be moved up in height depending on the type of performance (opera, concert, drama) and the performance of the singers and instruments, as in other theatres (Tronchin, 2013; Tronchin and Knight, 2016).

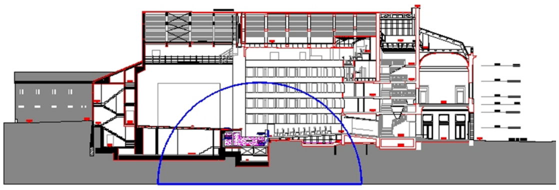

Fig. 1 – The theatre and the orchestra pit

A series of rotating acoustic boards, made of wood, were hung on the ceiling of the pit: one side of the panels is able to capture and tune at different frequencies, while the other side reflects the direct waveforms. The motion of the boards towards the stalls could generate a cavity below the stage, with a distinct volume and neck, and therefore tuned to different frequencies.

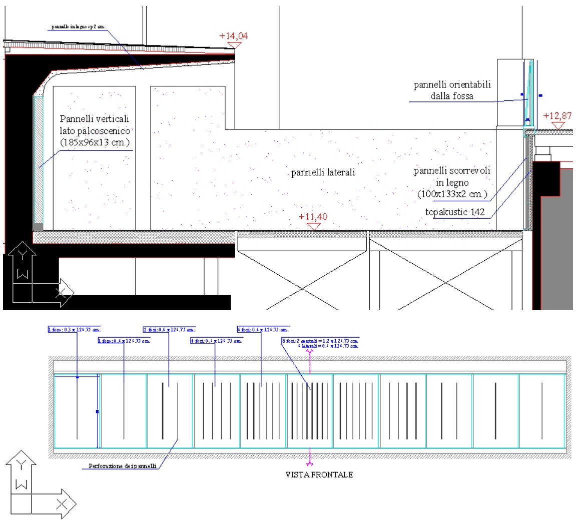

Fig. 2 – The orchestra pit: details

Particular attention was given to the aesthetics and acoustics of the fencing, which is located in front of the orchestra pit. The fence creates a strong early reflection of the sound from the pit to the stage, acting as a sound barrier from pit to stalls, based on its direction. For these reasons, its boundary can contribute to the diffusion of the sound in the room and significantly affects the balance between pit and stage. The fence was therefore designed with different orientations, helping performers to perform better on the stage and in the pit.

2.2 The Design of Diffusion in the Stage

The stage in an opera is generally rectangular and the walls are made of concrete. This kind of shape, with two parallel side walls, does not provide the performers, particularly the musicians, with great acoustics throughout the stage. Furthermore, although a good acoustic chamber could solve these difficulties in orchestral configuration, some strong reflections cannot be avoided during a performance. To solve these issues, a series of diffusing panels were installed on the stage of the Teatro Vittorio Emanuele in Messina, Sicily, together with solutions for sound insulation (Caniato et al., 2015, 2016 and 2018).

The calculation followed the well-known number theory (Tronchin et al., 2020), and consequently diffractal boards were drawn up in accordance with the resulting frequencies. The stage dimensions permitted the design of modular, low frequency tuned panels, as shown in Fig. 4. A series of diffusing panels was also introduced to the orchestra pit, at the same theatre. A pyramid tracing software package, which could properly take diffusion into consideration, was used to detect the suitable position of panels both on stage and in the orchestra pit. The numerical model is shown in Fig. 3.

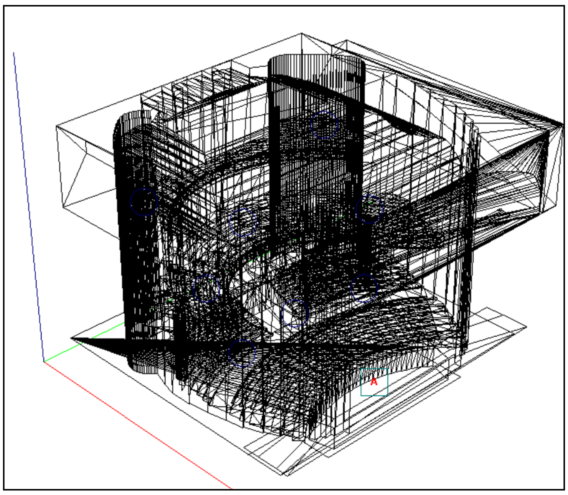

Fig. 3 – The model of the theatre Vittorio Emanuele in Messina

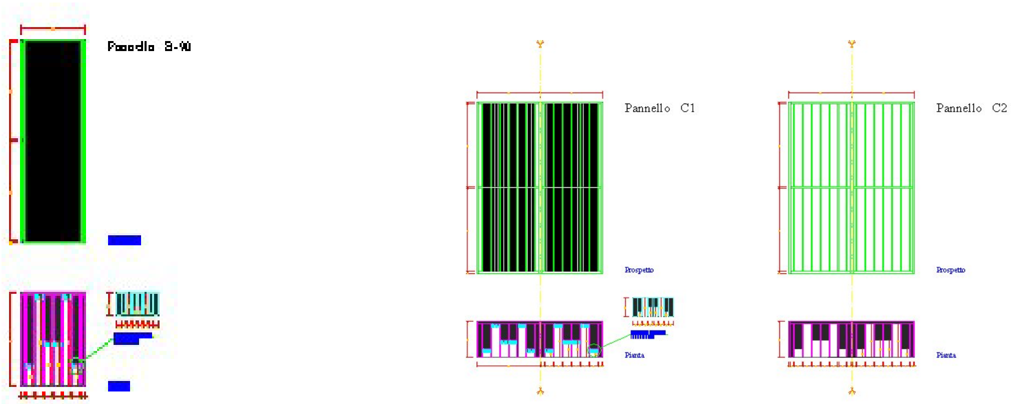

Fig. 4 – Diffusing panels in the orchestra pit (left) and in the stage (right)

Due to the energetic decay in the computed impulse responses, the optimal distribution of the diffusing surface was also calculated. In Fig.s 5–7, distinct feasible panel locations are shown, with the corresponding energy decay impulse responses achieved for each setup.

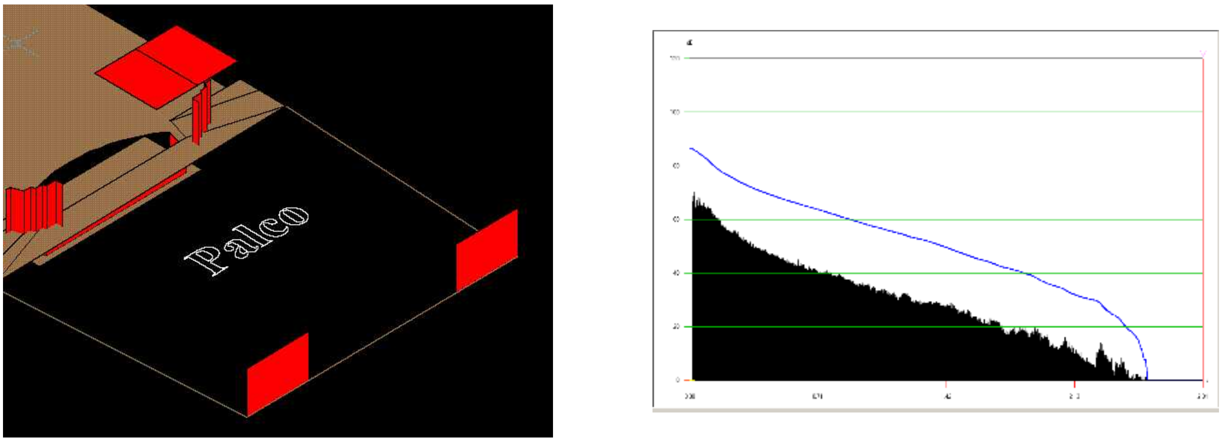

Fig. 5 –Solution A for the placement of the diffusing panels and their influence on the IRs

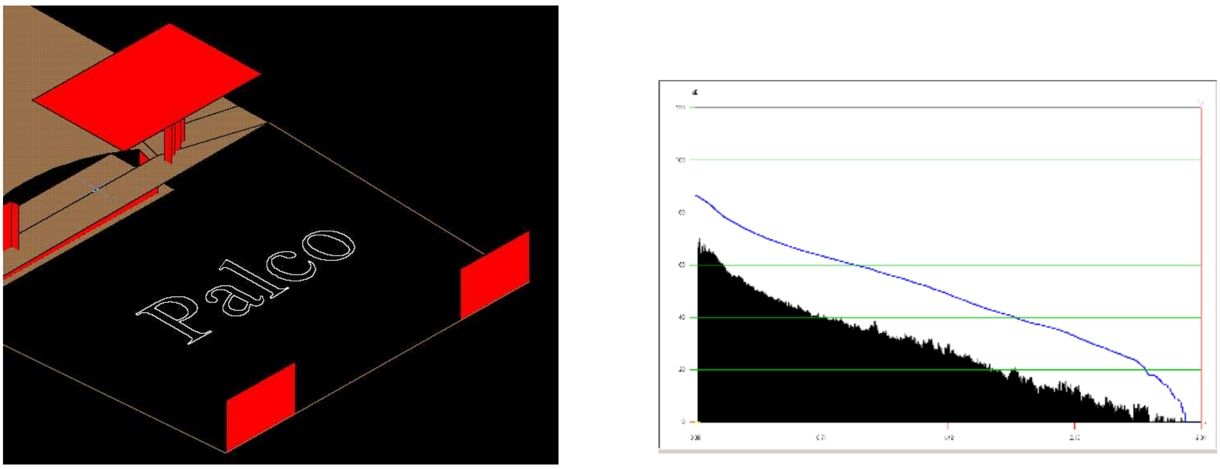

Fig. 6 – Solution B for the placement of the diffusing panels and their influence on the IRs

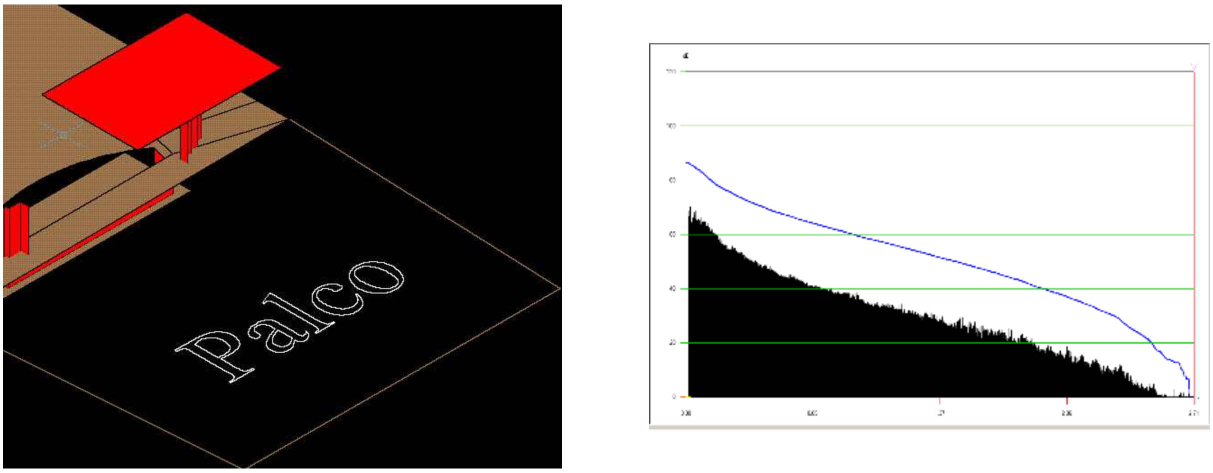

Fig. 7 – Solution C for the placement of the diffusing panels and their influence on the IRs

2.3 The Design of the Acoustic Chamber

Today, the acoustic design of the performing area in concert halls and especially in opera houses also includes the realization of the orchestra chamber, since an effective design of this can significantly improve the balance between all orchestral sections. However, the effectiveness of the chamber depends not only on its acoustic properties: it also depends on other variables such as simplicity, versatility and quickness of assembling and deassembling. In the Teatro Comunale in Treviso, the acoustic chamber was designed with three different configurations of the hall with reference to the position of the orchestra pit and, consequently, the type of performance. Considering a performance by a soloist, for example, the pit can be elevated to the stage level and cover the whole area of the acoustic chamber, which was specifically designed for this theatre. Support (ST1) and Early Ensemble Level (EEL), are among the most important acoustic parameters for the perception of music by the performer (Shimokura et al., 2011). With a triangular acoustic chamber, the optimum ST1 values of -11 to -13 dB were achieved. Furthermore, the strength and reverberation times in the receiver positions in stalls with a triangular shape were preferable.

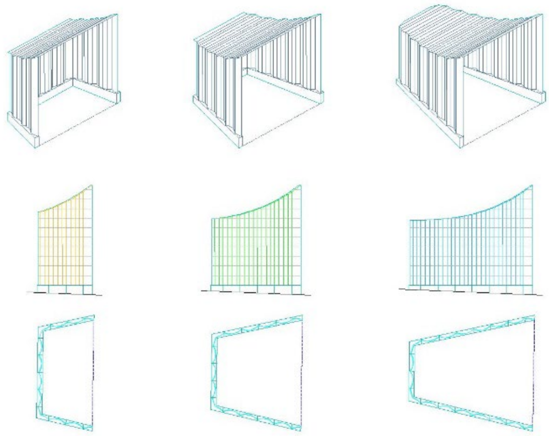

Fig. 8 – The three configurations of the acoustic chamber

3. Results

The results discussed in this paper emphasise the fact that the design process involves many different considerations, ranging from acoustic requirements to flexibility. What has been shown is that the systematic and detailed study of the various problems that can occur within a space dedicated to musical performance can lead to simple and effective solutions from the point of view of both the architecture and the quality of the acoustics. This is also replicable in infrastructures where prefabricated components are assembled and its modelling is crucial for performance (Caniato et al., 2019; Tronchin and Fabbri, 2017; Tronchin and Knight, 2018; Tronchin et al., 2018). Moreover, these solutions allow performers to perform their work in the best way, thus also guaranteeing better experience for end users.

4. Conclusion

In this paper, some examples of devices which can enhance the acoustic quality in opera houses were presented. However, the design process should not only consider acoustic performance but also many different aspects, including flexibility and costs. It is worth noting that in several cases, very valuable examples of acoustic devices (e.g. turning panels, etc.) are not normally used by the staff, i.e. technicians working in the theatre. In order to avoid this circumstance, the staff should be fully involved in the design process.

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